Geophysical Research Abstracts
Vol. 20, EGU2018-13950, 2018
EGU General Assembly 2018
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Observation and simulation of ethane at 23 FTIR sites

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Ethane is the most abundant non-methane hydrocarbon in the Earth atmosphere. Its main sources are of anthropogenic origin, with globally 62% from leakage during production and transport of natural gas, 20% from biofuel combustion and 18% from biomass burning (Xiao et al., 2008). In the Southern hemisphere, anthropogenic emissions are lower and so biomass burning is a more significant source. The main removal process is oxidation by the hydroxyl radical (OH), leading to a mean atmospheric lifetime of 2 months.

Until recently, a prolonged decrease of its abundance has been documented, at rates of -1 to -2.7%/yr, with global emissions dropping from 14 to 11 Tg/yr over 1984-2010 owing to successful measures reducing fugitive emissions from its fossil fuel sources.

However, subsequent investigations have reported about an upturn in the ethane trend, characterized by a sharp rise from about 2009 onwards. The ethane increase is attributed to the oil and gas boom in North America (Helmig et al., 2016), although significant changes in OH could also be at play (e.g., Turner et al., 2016).

In the present contribution, we report the trend of ethane at 23 ground-based Fourier Transform Infrared (FTIR) sites spanning the 80^{o}N to 79^{o}S latitude range, focusing more specifically on the 2010-2015 time period. A significant ethane rise (3-5%/yr) is a common feature for all sites in the Northern Hemisphere while for the Southern Hemisphere, the rates of changes are not different from zero (2-sigma).

Observations are compared with dedicated model simulations by the 3-D Chemistry Climate Model EMAC (ECHAMS/MESSy Atmospheric Chemistry), driven by ECMWF analysis data on a $\sim$1.8° x 1.8° horizontal grid and implementing the Master Chemical Mechanism. Various emission scenarios are included in order to support data interpretation. The usual underestimation of the NMHCs emissions in the main inventories is confirmed here for RCP85 (Representative Concentration Pathway Database v8.5), scaling them by 1.5 is needed to capture the background levels of atmospheric ethane. Moreover, additional and significant emissions ($\sim$7 Tg over 2009-2015) are needed to capture the ethane rise in the Northern hemisphere. Attributing them to the oil and gas sector and locating them in North America allows EMAC to produce adequate trends in the Northern hemisphere, but not in the Southern hemisphere, where they are overestimated.

Acknowledgments

This research received support from the F.R.S.–FNRS (Brussels), under Grant J.0147.18.

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